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TITLE: High through-put copper CMP with reduced erosion and dishing

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Selectivity

US-CL-CURRENT: 438/200; 438/500, 438/501

CLAIMS:

What is claimed is:

1. A method of planarizing a substrate surface containing a copper or copper alloy layer disposed on a barrier layer comprising: (a) polishing the substrate surface on a first platen to reduce a copper or copper alloy layer at a first removal rate; and (b) polishing the substrate on a second platen to remove the copper or copper alloy layer at a second removal rate less than the first removal rate.

2. The method according to claim 1, further comprising removing the barrier layer on a third platen.

3. The method according to claim 1, wherein the first removal rate greater than about 5,000 .ANG. per minute; and the second removal rate is between about 250 .ANG. per minute and about 3,000 .ANG. per minute.

4. The method according to claim 2, wherein the barrier layer comprises tantalum (Ta) or tantalum nitride (TaN) and is disposed on a dielectric material.

5. The method according to claim 1, wherein step (b) is performed at a selectivity of copper:barrier layer of greater than about 100:1.

6. The method according to claim 5, wherein step (b) is performed under conditions such that dishing within the dense array is about 600 .ANG. or less.

7. The method according to claim 6, wherein steps (a) and (b) are performed on a rotating, stationary, or linear fixed abrasive polishing pad mounted on the first and second platens, respectively.

8. The method according to claim 7, wherein the first and second platens are rotated during steps (a) and (b) by at less than about 60 rpm or the first and second belts disposed on the first and second platens, respectively, are moved linearly at a rate of less than about 30 inches per second.

9. The method according to claim 7, further comprising cleaning the polishing pads by removing debris and polishing by-products between each substrate.

10. The method according to claim 7, further comprising recycling the chemical agent.

The present invention provides cleaning processes and solutions for removing residual particles remaining after polishing aluminum-containing layers. The cleaning processes are especially useful for cleaning polished surfaces of aluminum features, such as interlayer connectors or conducting lines. In particular, the present invention inhibits the corrosion of the polished aluminum features caused by cleaning solutions containing deionized water.

Detailed Description Text (11):
The structure of FIG. 1 is then planarized. FIG. 3 illustrates the IC device after it has been planarized, preferably by an AP process. AP processes may vary according to the operating requirements of a given machine, such as the polishing pad used and the tooling requirements. AP processes for planarizing metallic layers, including aluminum-containing layers, generally use a slurry containing abrasive particles and at least one oxidant. The oxidant oxidizes the upper surface of the metal layer, which the abrasive particles then polish away. Preferably, the abrasive particle is aluminum oxide. Any of the known oxidants, including those used in abrasive planarization of tungsten such as hydrogen peroxide, potassium iodide, or ammonium persulfate, may be employed in the preferred AP process. A preferred slurry that can be employed in the present invention is an aluminum polishing slurry available from Cabot Corporation.

Detailed Description Text (12):
Metal layer 40 and metal liner 44 are planarized by polishing to an end-point near the upper surface of dielectric layer 30. The planarization may proceed further than this end-point--since the polishing is not selective for aluminum--and thus remove part of the upper surface of dielectric layer 30, but this is not preferred. After metal layer 40 has been planarized, interlayer connectors 42 remain. Interlayer connectors 42 are electrically isolated from one another by the remaining portions of dielectric layer 30.

Detailed Description Text (14):
The planarization process produces contamination, inter alia, in the form of residual slurry particles, residual polishing particles, and residual dielectric particles. The residual slurry particles are abrasive aluminum oxide particles left by the slurry. The residual polishing particles are aluminum oxide particles originating from metal layer 40 which remain after the polishing action. While both types of residual particles are aluminum oxide, they differ in terms of structure and type (e.g., particle size and mechanical properties). The residual dielectric particles are formed if the planarization process removes part of dielectric layer 30. The residual particles are generally loose and unattached to the planarized surface, at most tending to adhere to the interface between the aluminum and silicon oxide layers, and are not chemically bonded.

Detailed Description Text (20):
Chelating agents are added because of their ability of the agents to chelate, or combine with the residual particles to form a chemical compound. These additives increase the capacity of the cleaning solution to retain metals in solution and remove the residual particles from the vicinity of the planarized surface. Suitable chelating agents include the following organic acids and their salts: ethylenediaminetetraacetic acid (EDTA); butylenediaminetetraacetic acid; cyclohexane-1,2-diaminetetraacetic acid; diethylenetriaminepentaacetic acid; ethylenediaminetetrapropionic acid; (hydroxyethyl) ethylenediaminetriacetic acid (HEDTA); methyliminodiacetic acid; propylenediaminetetraacetic acid; nitrolotriacetic acid (NTA); citric acid; tarric acid; gluconic acid; saccharic acid; glyceric acid; oxalic acid; phthalic acid; maleic acid; mandelic acid; malonic acid; lactic acid; salicylic acid; catechol; 8-hydroxquinoline; N,N,N',N'-ethylenediaminetetra(methylenephosphoric) acid; and mixtures thereof. Citric acid, EDTA, and their salts are the preferred chelating agents. Citric acid and citric acid salts act as chelating agents for residual alumina particles. EDTA and its salts acts as chelating agents for residual metal ions. Citric acid and/or the citric acid salt is added in the same amounts indicated above. EDTA and/or the EDTA salt is added in the form of a solution, preferably about a 1% solution to about a 10% solution, and more preferably a 5% EDTA solution. Generally, when the cleaning solution contains about 5 liters DI water, preferably about 1 to about 100 ml of such a EDTA acid solution is added, and more preferably about 50 ml is added. The amounts of water and EDTA, EDTA salt, citric acid, and/or citric acid salt solutions, however, can vary depending on the type of equipment used in the cleaning process.

Detailed Description Text (22):
Oxidants may also be added to the cleaning solution or applied to the polished wafer directly after polishing and before subsequent cleaning steps. Preferably, the

oxidant(s) is applied to the polished wafer directly after polishing and before subsequent cleaning steps. Oxidants help the cleaning solution maintain the passivative environment which protects the exposed metal or aluminum structures. In particular, when aluminum surfaces are exposed to water, the oxidants create and preserve a thin continuous layer of hydrated aluminum oxide at the aluminum-water interface. Oxidants that may be added to the cleaning solution include ozone, hydrogen peroxide, peroxy salts, ammonium persulfate, and the like, or mixtures thereof. Preferably, ozone is used as the oxidant. A DI water solution containing about 1 to about 20 ppm ozone, preferably about 10 ppm, may be employed on the polisher during a final polish rinse step which may last about 30 seconds.

Detailed Description Text (26):
Any suitable means or apparatus may be used to carry out this cleaning process. For example, the cleaning process could be carried out by immersing IC device 10 in a bath containing the cleaning solution. The cleaning process could also be carried out by using spray processing tools common in the industry. This cleaning process could also be carried out by employing the cleaning solution in an appropriate cleaning station built into a wafer polishing tool.

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L19: Entry 2 of 9 File: USPT Jul 24, 2001

DOCUMENT-IDENTIFIER: US 6265781 B1
TITLE: Methods and solutions for cleaning polished aluminum-containing layers, methods for making metallization structures, and the structures resulting from these methods

Abstract Text (1):
Methods for making an aluminum-containing metallization structure, methods and solutions for cleaning a polished aluminum-containing layer, and the structures formed by these methods. The methods for making the aluminum-containing metallization structure are practiced by providing a substrate, forming a metal layer with an upper surface containing aluminum over the substrate, polishing the metal layer, and contacting the polished surface of the metal layer with a solution comprising water and at least one corrosion-inhibiting agent. The method for cleaning the polished aluminum-containing layer is practiced by contacting a polished aluminum-containing layer with a solution comprising water and a corrosion-inhibiting agent. In these methods and solutions, the water may be deionized water, the corrosion-inhibiting agent may be citric acid or one of its salts, and the solution may contain additional additives, such as chelating agents, buffers, oxidants, anti-oxidants, and surfactants. These methods and solutions reduce the corrosion caused by DI water used in cleaning polished aluminum-containing layers and maintain a passivative environment which protects the exposed aluminum structures.

Brief Summary Text (3):
Abrasive planarization ("AP") techniques, such as chemical-mechanical planarization processes, are frequently used to planarize the surface layers of a wafer during fabrication of integrated circuits (ICs). In AP processes, a wafer is generally pressed against a polishing pad in a slurry solution under controlled chemical, pressure, velocity, and temperature conditions. The slurry solution generally contains abrasive particles that mechanically remove the surface layer and may contain chemical agents which attack the surface layer. The polishing pad is generally a planar pad made from a relatively soft, porous material. After being planarized, the surface layer is cleaned to remove materials introduced during the AP process by the slurry, polishing pad, or wafer.

Brief Summary Text (5):
After the metallic layers are planarized, residual particles from the slurry, polishing pad, or wafer remain on the planarized surface. The residual materials include aluminum oxide particles (also known as alumina) from both the slurry and metallic layer, as well as particles from the dielectric layer. All of these particles cause defects in the planarized surface. Thus, it is necessary to clean these residual particles from the planarized surface. Several methods of post-AP cleaning, such as using hydrofluoric (HF) acid or ammonium hydroxide (NH.sub.4 OH) solutions, are described in U.S. Pat. Nos. 5,498,293, 5,662,769, and 5,679,169, the disclosures of which are incorporated herein by reference.

Brief Summary Text (8):
The present invention includes methods for making an aluminum-containing metallization structure and the metallization structures formed thereby. The methods are practiced by providing a substrate, forming a metal layer with an upper surface containing aluminum over the substrate, polishing the metal layer, and contacting the polished surface of the metal layer with a solution comprising water and at least one corrosion-inhibiting agent. The substrate may be a silicon substrate. The metal layer may be polished by an abrasive planarization process. The corrosion-inhibiting agent may be citric acid or a salt thereof. The solution may contain additional additives, such as chelating agents, buffers, oxidants, anti-oxidants, and surfactants.

Detailed Description Text (2):